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IMPACT OF EARLY COCHLEAR IMPLANTATION ON LANGUAGE
DEVELOPMENT ON CHILDREN WITH PRELINGUAL HEARING LOSS

by

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A Research Paper
Submitted in Partial Fulfillment of the Requirements
for the
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RESEARCH PAPER APPROVAL

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DEVELOPMENT ON CHILDREN WITH PRELINGUAL HEARING LOSS

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A Research Paper Submitted in Partial
Fulfillment of the Requirements
for the Degree of
Masters of Science
in the field of Communication Disorders and Sciences

Approved by:

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The objective of this research paper is to discuss the impact cochlear implants can have on language development on children with pre-lingual hearing loss. The discussion will begin with an overview of how the auditory process works in a normal hearing person. Next, the three types of hearing loss will be discussed, as well as information regarding the differences between hearing aid and cochlear implants. Subsequently, a debate about the importance of early cochlear implantation, parental concerns, and finally future considerations will be addressed.

Speech-language pathologists (SLPs) play an important role in the lives of individuals with hearing losses. Patients do not solely rely on audiologists for identification, and treatment. It is in the scope of practice for SLPs to conduct hearing screenings. SLPs also provide aural rehabilitation services, perform basic hearing aid checks, collaborate with and refer clients to audiologists, and assess and provide intervention for auditory processing disorders.

Individuals who seek help from SLPs often receive hearing screenings simply to eliminate the possibility of hearing problems. Many times SLPs are the first to recognize a potential hearing problem. They cannot diagnose a hearing loss, but if the hearing screening is

failed the SLP sends referrals to audiologists. After a diagnosis is determined the client returns to the SLP for rehabilitation services. Young children with extreme hearing losses need intense services to allow them the best possibility of reaching the level of their normal hearing peers once they reach school age.

Normal Hearing Process

Infants born with normal hearing thresholds possess a number of auditory skills crucial to fostering language growth; many of these proficiencies appear to be present as early as birth or beforehand (Tomblin, Barker, Spencer, Zhang, & Gantz, 2005). The act of inputting sound from outside the body and changing it into meaningful words and sentences within the brain is a complicated process that begins during the gestational period. The process is initiated when sound travels to the ear, which consists of three anatomical areas. The first area that the sound waves reach is the outer ear. From the outer ear it moves to the middle ear, and finally to the inner ear. These three areas form the peripheral auditory pathway. Once the sound passes through the structures of the inner ear it moves on to the auditory nerve, also known as the 8th Cranial Nerve (CN). The signal is transmitted along the auditory nerve to the brainstem and completes its course

within the auditory cortex. The auditory nerve, brainstem, and auditory cortex make up the central auditory pathway.

The Outer Ear

Each area of the ear is composed of other important anatomical structures. The outer ear has two primary components. They are the auricle and the external auditory meatus (EAM) or the ear canal. The auricle collects the sound and funnels it to the external auditory meatus or ear canal. The ear canal is a tube approximately one inch and leads medially into the body (Roseberry-McKibbin & Hedge, 2011). The auricle and ear canal provide four protective mechanisms. First, the production of cerumen prevents foreign objects from reaching the eardrum, which ultimately reduces the risk of infection. Secondly, the s-shaped curve of the ear canal protects from damage to the middle ear. Third, tiny hair follicles within the EAM are designed to work similarly to the cerumen in the prevention of infection (Roseberry-McKibbin & Hedge, 2011). Lastly, the opening to the ear canal is narrow to prevent large items from getting lodged.

The Middle Ear

The middle ear has four major anatomical structures: the tympanic membrane, the ossicular chain, two middle ear muscles, and the Eustachian tube (Roseberry-McKibbin &

Hedge, 2011). The tympanic membrane is attached to a segment of the middle ear. It vibrates in response to the sound waves and sends the signal on to the ossicular chain. The malleus, the incus, and the stapes form the ossicular chain. The three ossicles are interconnected. The malleus is attached to the tympanic membrane (Roseberry-McKibbin & Hedge, 2011). Therefore, when the tympanic membrane vibrates the ossicles too vibrate, which transfers sound through the middle ear. The two primary muscles of the middle ear are the tensor tympani and the stapedius muscles. Both muscles connect to the ossicular chain and act as a protective mechanism. The Eustachian tube travels from the middle ear to the nasopharynx (Roseberry-McKibbin & Hedge, 2011). It does not directly transfer sound waves, but it does help ensure protection to the auditory pathway by equalizing air pressure, draining mucus, and preventing reflux from entering the middle ear (Roseberry-McKibbin & Hedge, 2011).

The Inner Ear

One purpose of the inner ear is to change the sound energy into a form of energy that the brain can understand. It also provides information about the body's position and movement, and helps regulate balance. The inner ear is composed of three bony structures: the vestibule, the

semicircular canal, and the cochlea. The vestibule and semicircular canals contain hair cells that detect the movement of the perilymph and endolymph fluids. This in turn maintains and stabilizes the body's balance and movements (Roseberry-McKibbin & Hedge, 2011). The cochlea can be divided into three segments including the scala vestibuli, scala media, and scala tympani. The Organ of Corti also lies within the cochlea. There is one row of inner hair cells and three rows outer hair cells that line the Organ of Corti.

Once sound has passed through the outer, middle, and inner ear it reaches the auditory nerve where it is then transferred to the brainstem and eventually to the brain to be decoded into meaningful messages.

Types of Hearing Loss

There are three types of hearing loss. One type, conductive hearing loss, is due to problems, complications, or malformations of the outer or middle ear. The inner ear is fully capable of transferring sounds. This type of loss simply reduces the volume of the signal. Typically, individuals that experience a conductive hearing loss can receive some type of treatment making the loss temporary.

Sensorineural hearing loss, a second type, is due to problems within the inner ear or auditory nerve. Often the

individual experiences a reduction in the volume and clarity of the signal. This type of loss is more complicated to treat and often is not possible to treat even with surgery resulting in a permanent loss (Roseberry-McKibbin & Hedge, 2011).

Mixed hearing loss is the third type of hearing loss that can occur in children. As the name implies it is a combination of both conductive hearing loss and sensorineural hearing loss.

Hearing Aids vs. Cochlear Implants

Hearing aids and cochlear implants are the two ways to enhance one's hearing abilities. Individuals who experience any type of hearing loss will potentially be fit with one or the other if proper medical treatment is sought (Roseberry-McKibbin & Hedge, 2011). The purposes of hearing aids are well known even to those that do not have first hand experience. Many people, however, have never heard of a cochlear implant if they do not have or know someone who uses one.

Types of Hearing Aids

Hearing aids are small electronic devices inside the ear. They are placed in the entrance to the ear in the EAM. They are typically molded to fit each individual ear and amplify sound as it is delivered to the ear canal.

There are a variety of hearing aids to fit the needs and preferences of individuals. For those who prefer a more inconspicuous fix the eyeglass hearing aid or body aid might be a suitable option (Roseberry-McKibbin & Hedge, 2011). However, more commonly chosen hearing aids include the behind-the-ear model, in-the-canal model, completely-in-the-canal model, and in-the-ear model (Roseberry-McKibbin & Hedge, 2011).

Analog and Digital Hearing Aids

Another consideration, which has to be made when choosing a hearing aid, is deciding between analog hearing aids and digital hearing aids. Analog hearing aids create patterns of electric voltage that correspond to the sound input (Roseberry-McKibbin & Hedge, 2011). All analog hearing aids consist of the same basic components: a microphone, an amplifier, a receiver, a power source (batteries), and volume control (Roseberry-McKibbin & Hedge, 2011). The microphone in the device brings in the sound and alters the sound energy to electrical energy as it passes through the hearing aid (Roseberry-McKibbin & Hedge, 2011). The receiver then takes the electrical energy and converts it back into sound waves that can be passed on to travel along the remaining auditory pathway (Roseberry-McKibbin & Hedge, 2011). The amplifier

increases the volume of the signal, which can be modified to meet individual needs by adjusting the volume control. The battery gives the device power to function properly. Speech-language pathologists must remain educated on hearing aids and the components in order to clean, maintain, and adjust them as necessary (Roseberry-McKibbin & Hedge, 2011).

Unlike the analog hearing aids the digital hearing aids have a microchip with computerized technology. This aid takes the sound that is inputted and changes it to a number system of ones and zeros. The numbers are then translated by a computer located somewhere on the body (Roseberry-McKibbin & Hedge, 2011).

Technological Advances of Hearing Aids

Technological advances have proven to effectively enhance and improve the quality of hearing aids that are available (Roseberry-McKibbin & Hedge, 2011). Not only can they be custom fit to each individual, which provides more comfort, but the microphones and amplifiers have become more advanced as well. The microphones are more sensitive to sound, which enables the listener to "pick up" on more of the speech that is taking place during a conversation (Roseberry-McKibbin & Hedge, 2011). The amplifier has been adjusted to provide sound with as little distortion as

possible (Roseberry-McKibbin & Hedge, 2011). This improvement allows for better clarification of what is being said. Hearing aids are now programmable. This feature allows individuals to change settings depending on the environment. For example, a person with a hearing impairment can have the aid on one setting while home alone watching television or on a different setting to help drown out unwanted background noise while attending a social gathering.

Cochlear Implants

Though hearing aids are beneficial to many, individuals with severe or profound hearing loss often do not receive as much benefit (Roseberry-McKibbin & Hedge, 2011). When this occurs, candidacy for a surgical procedure called cochlear implantation becomes an option to consider. The introduction of cochlear implants has significantly impacted the educational, as well as communication opportunities for children with severe to profound sensorineural hearing loss (Geers, Tobey, Moog, & Brenner, 2008). Cochlear implants are widely used to treat profound perceptive hearing loss (Govaerts et al., 2002). Cochlear implants (CIs), in particular, have become widely embraced as an aid to exposing the child with severe-to-profound hearing loss to a quality of sound experience not

available with hearing aids alone (Nicholas & Geers, 2007). A cochlear implant is an electronic device that is placed in the cochlea, a structure in the inner ear, and delivers sound directly to the auditory nerve. When too many inner hair cells within the cochlea are damaged the hearing aid provides little improvement. The cochlear implant bypasses the damaged hair cells, which gives individuals with hearing impairments an opportunity to perceive sound again (Roseberry-McKibbin & Hedge, 2011).

Cochlear implants have four basic components: a microphone, a processor, an external transmitter, and an implanted receiver. The microphone tracks the sound waves and converts them into electrical signals (Roseberry-McKibbin & Hedge, 2011). The processor's job is to filter out external sounds so sound waves from speech are the primary impulses reaching the microphone (Roseberry-McKibbin & Hedge, 2011). The external transmitter is a magnetic unit worn on the outer skull. This is attracted to an internal magnetic unit, or implanted receiver, under the skin. The external transmitter sends signals to the implanted receiver, which in turn stimulates the auditory nerve (Roseberry-McKibbin & Hedge, 2011).

Technological Advances of Cochlear Implants

Technology has also proven beneficial to the effectiveness of cochlear implants. They are now equipped with multiple channels. These channels, also known as electrodes, are capable of stimulating various portions of the cochlea to allow for tonal perceptions (Roseberry-McKibbin & Hedge, 2011). Individuals with cochlear implants are capable of hearing voices at the normal conversation level, and can catch on to rhythm and rate of speech (Roseberry-McKibbin & Hedge, 2011). These devices give hope to adults with profound hearing impairments, as well as the parents of infants and young children with congenital deafness. Children who receive an implant early in life, followed by a period of appropriate rehabilitation, achieve speech and language skills that exceed levels observed in profoundly deaf children with hearing aids (Geers, 2004). When an infant is identified at birth as having profound sensorineural hearing loss (SNHL), intervention can begin soon after the child leaves the birthing hospital. Many activities accompany this intervention, such as family education, family grieving, family acceptance, infant hearing-aid fittings, completing a reasonable hearing-aid trial, and measuring hearing-aid benefit (Tomblin et al., 2005).

Individuals who receive no benefit from hearing aids go through various examinations from several professionals including but not limited to audiologists, SLPs, and psychologists to determine candidacy for cochlear implants (Roseberry-McKibbin & Hedge, 2011). In the past, professionals encouraged these candidates, especially children, to test hearing aids first. Children fitted with a cochlear implant at a relatively late age, after hearing aid application in the first year of life, perform no better than children implanted at the same age without any previous hearing aid application (Colletti, Carner, Miorelli, Guida, Colletti, & Fiorino, 2005). When a profound hearing loss has been diagnosed, some experts feel very strongly against a trial period with hearing aids before beginning cochlear implantation and the rehabilitative phase (Colletti et al., 2005). Colletti and colleagues (2005) argue that hearing aids are an unnecessary step simply prolongs auditory deprivation for no beneficial purpose.

Early Intervention: How important is it?

Early implantation is difficult because of the complexity of precise determination of hearing abilities, hearing-aid advantage, as well as the risks of surgery with very young children (Tomblin et al., 2005). Studies seem

to suggest that receiving an implant before the age of two could lead to greater and faster improvements in speech perception and speech production than implantation later in childhood (Schauwers, Gillis, Daemers, De Beukelaer, & Govaerts, 2004). The source of much debate and the topics of many research studies regarding hearing impairments and cochlear implants stem around one topic: the importance of early cochlear implantation. Scientists, professors, and doctors around the world cannot agree on what age is the most beneficial to implant a child. Because of medical advances it is now safe to provide a child with a cochlear implant within the first year of life (Colletti et al., 2005). However, the question still remains, just because the surgery can be done, should it? While many professionals believe the answer is yes, still some say no. Therefore, it is important to determine whether there are measurable benefits of early implantation that counterbalance these challenges (Tomblin et al., 2005).

In 2005 Colletti and colleagues conducted a study to determine the importance of early intervention. This team believes that the younger the implantation process can take place the better the outcome. Because of safety of surgical procedures and positive rehabilitative results, experts have recently reduced the age of implantation to 12

months or younger (Colletti et al., 2005). This directly correlates to a decrease in the amount of auditory deprivation experienced by children with sensorineural hearing loss. Children fitted with cochlear implants at an early age improve their expressive and receptive language abilities and have been shown to develop speech and language skills at an equivalent rate as normal hearing children (Colletti et al., 2005). Another positive finding was accelerated rate of growth, specifically children implanted at younger ages tend to demonstrate growth and improvement at a more rapid pace than children implanted at older ages (Colletti et al., 2005). No noticeable differences have been detected between children implanted at different ages during the first six months of cochlear implant use (Colletti et al., 2005). At longer follow-ups (12-24 months), a slower increase in performance was observed in older age groups (Colletti et al., 2005). It was clear when comparing children implanted during the first year of life with those implanted between 12 and 36 months, there is roughly a delay of one year in reaching the same performance levels for children implanted after a year (Colletti et al., 2005).

As children grow and expressive communication develops, typically children can be expected to follow a

certain progression of behaviors. Around six months of age a range of vocalizations are produced and a variety of facial expressions are seen. By 12 months children are babbling using several consonant-like sounds, turn-taking, imitating gestures or vocalizations, pointing, and communicating with a purpose of engaging in joint attention or making requests. At 18 months children use different sounds that are similar to short words or sentences, use gestures and vocalize to direct an adults' attention to an object, and produce few meaningful words. By 24 months children have ten to 15 meaningful words in their vocabulary and use two word meaningful sentences. Around 36 months of age children speak in three to five word sentences, talk about past and future, ask questions (who, what, why, etc.), and have a vocabulary of approximately 100-200 words.

As previously stated the onset of babbling occurs between six and eleven months for typically developing children. Colletti et al. (2005) found that children implanted between five and six months of age started babbling approximately two months postoperative, or seven to eight months of chronological age. Children implanted between ten to 11 months of age developed babbling at 12-13 months of age. While these results show no significance

differences between implantation at six months or twelve months, it can be concluded the earlier children received cochlear implants the closer they will be in developing with their normal hearing peers. The results obtained in the present study suggest early CI surgery tends to produce normalization of audio-phonologic parameters to such an extent that we can consider a child implanted at six months as having a language-learning rate comparable with that of his or her normally hearing peers within a space of six to twelve months (Colletti et al., 2005). Similarly, Tomblin et al. (2005) reported, "the earlier implantation occurred, the sooner the children were likely to develop expressive language at a rate commensurate with normal-hearing peers" (p. 864).

Similar to the previously discussed study by Colletti and colleagues (2005), a study by Schauwers and colleagues (2004) and others investigated the onset of babbling following cochlear implantation in children with profound hearing loss. This group examined children that were implanted between five and 20 months of age. Results indicated all children observed began babbling somewhere between one and four months following activation of the cochlear implant. The children who received implants at the youngest ages (five-eight months of age) experienced an

onset of babbling at a chronological age equal to normal hearing peers. While all children did eventually start babbling and developing expressive language it was evident that younger children have a much better chance of developing alongside normal hearing peers (Schauwers et al., 2004).

In 2007, a study conducted by Nicholas & Geers claimed two hypotheses. First, better language outcomes and faster language growth are associated with younger age at implant, better pre-implant aided thresholds (i.e. hearing aids), and longer duration of implant use (Nicholas & Geers, 2007). Secondly, children who receive a CI before their second birthday can be expected to achieve age-appropriate spoken language by four and a half years of age (Nicholas & Geers, 2007).

Children with better pre-implantation residual hearing exhibited steeper growth of language with greater implant experience than children with less pre-implantation aided hearing (Nicholas & Geers, 2007). Across the language measures, children who received an implant at age 12 months exhibited language outcomes at age three and a half years that were not achieved by those who received an implant at age 18 months until age four and a half years (Nicholas & Geers, 2007). This finding showed a six-month difference

in implantation age could result in a delay of at least a year. It further indicates the importance of early intervention for hearing impairment using cochlear implants results in reaching developmental milestones of language at an earlier age, and potentially a level of normal hearing peers by the time they are ready for school.

Children with profound congenital hearing loss or pre-lingual deafness are at an increased risk of exhibiting a language delay approximately four to five years behind normal hearing peers by the time they reach high school (Blamey et al., 2001; Geers et al., 2008). Unlike those with post-lingual hearing loss, children with pre-lingual hearing loss lack the auditory memory of spoken language to help them (Fryauf-Bertschy, Tyler, Kelsay, Gantz, & Woodworth, 1997). A study conducted by Geers in 2004 examined age of implantation and duration of use as factors that might be determinates in whether children reach a level equivalent to that of their typical developing peers. For children who received a cochlear implant between ages two and four years, age at implantation was not strongly associated with speech perceptions, speech production, language, or reading skills demonstrated at age eight or nine years (Geers, 2004). There are two possible explanations for the lack of evidence supporting early

cochlear implantation. The first explanation may be "age two years is not young enough to show that advantage of early input" (Geers, 2004, p. 637). Many professionals believe there is a window of opportunity where a young child's immature brain still has a level of plasticity, which allows for more adaptation to auditory stimulation than a more mature brain (Tomblin et al., 2005). This time frame is also referred to as the critical language learning years. While this is a widely accepted concept, the age at which this plasticity reduces is still undetermined. Disputes about this period of language development include a disagreement on the age range. Some professionals believe the range is anywhere from as early as within the first 12 months of life to as late as five to six years of age (Govaerts et al., 2002). Though the age remains undetermined the general agreement is that children have the best chance to learn and develop language within the first five years of life (Suh, Cho, Kim, Chang, Kim, & Oh, 2009). The second explanation is "there may be an advantage for early implantation that is no longer apparent by age 8 years" (Geers, 2004, p. 637).

In 2002, Govaerts and colleagues conducted a study "to evaluate the outcome of cochlear implantation in young children in relation to the age at implantation" (p. 885).

In order to measure all participants in the study equally the authors gave the Categories of Auditory Performance (CAP), as well as the eventual integration into the mainstream school system. This study consisted of 231 participants, which included a control group of 113 and focused on children who received a cochlear implant before the age of two years, between two-four years, and between four-six years. Results indicated all children with profound hearing loss present at birth seemed to benefit from cochlear implantation.

A child older than four years of age has a small chance (roughly 20-30%) of reaching normal CAP scores and of being integrated into the mainstream school system; if this happens, it will only be at the age of six-seven years. A child between two and four years of age will most probably reach a normal CAP score but this will take three years, and only two out of three may be able to integrate (Govaerts et al., 2002, p. 890).

A child below the age of two is very likely to reach normal CAP levels without delay following implantation, "and almost all (90%) of these children will probably be able to

integrate into the mainstream school system at the kindergarten age" (Govaerts et al., 2002, p. 890).

Govaerts and colleagues (2002) demonstrated that children who receive cochlear implants at two years of age are closer to their normal hearing peers than those who are implanted at four years. This implies that normal development may be possible when auditory deprivation is minimized, specifically during critical language learning years.

Parents' Perspectives

The majority of research that focuses on infant hearing impairments discusses early cochlear implantation. One important aspect commonly overlooked is the opinions of parents of children with hearing impairments and how they can best be served by professionals at the time their child is diagnosed. In 1999 Luterman and Kurtzer-White conducted a study to determine the views of parents about their specific needs during the diagnostic process. The data was collected through a five-item questionnaire. The questions were as follows:

1. Would you have wanted to know that your baby was deaf at birth?
2. If not at birth, when?

3. What do you think would be the best way for a parent to be told about his/her child's hearing loss?
4. Who do you think should inform the parents about their child's bearing loss?
5. What do you think would be most helpful to parents in dealing with their child's newly identified hearing loss?

Results of question number one indicated that approximately 83% of parents would have wanted to know if their baby had a hearing loss at birth, while 17% responded that they would not want to know. Reasoning behind the response of not wanting to know was that parents felt the overwhelming process would diminish the bonding experience between parents and baby (Lutermna & Kurtzer-White, 1999). About 82% of parents reported that the best way to inform parents is through compassion and information from the audiologist. Parents used descriptive words such as "kindness, sympathy, calm, support", as well as "gently and with honesty" to express their thoughts on the best way for audiologists to act when giving the news to parents (Lutermna & Kurtzer-White, 1999, p. 15). The majority of responders reported that audiologists should be the professionals responsible for telling parents about the

child's hearing impairment, while other respondents indicated they preferred a team of professionals (Lutermna & Kurtzer-White, 1999). There were multiple responses on ways to help parents deal with their child's diagnosis. Some responses included contact with other parents of children with hearing impairments, a need for unbiased information, information about services, and support and help with coping (Lutermna & Kurtzer-White, 1999). This study alone provides information that shows the lack of satisfaction with the support and counseling they received. Every case is different and professionals need to adapt to meet the individual needs of each family.

Very few respondents to the Lutermna and Kurtzer-White (1999) survey reported that pediatricians should be responsible or even part of the team, which might be reflective of the lack of expertise. A study done by Mathews, Johnson, & Danhauer, in 2009, looked at pediatricians' knowledge of and comfort levels in dealing with children in need of cochlear implants. Approximately 24 of the 26 respondents claimed they had worked with children in the past five years that had sensorineural hearing losses; however, 61% reported never counseling parents about cochlear implants and 66% never even recommended cochlear implants as a treatment (Mathews et

al., 2009). Nearly half of these professionals reported feeling “completely uncomfortable” determining if children meet the criteria for being cochlear implant candidates, but were willing to refer parents to other specialists (Mathews et al., 2009, p. 136). Overall, the results of this study indicated that many pediatricians lack a significant amount of knowledge and confidence when working with patients with sensorineural hearing loss. This level of knowledge is essential in order to assist these patients and the families in finding the best possible treatments and outcomes (Mathews et al., 2009)

Other studies have investigated how difficult it is for parents to make decisions regarding their children and cochlear implants (Hyde, Punch, & Komesaroff, 2010). Many parents indicate cochlear implant centers are typically their main source of information (Hyde et al., 2010). While they appreciated such centers, they also felt the information they received tended to be biased and expressed primarily the positive factors more so than providing sufficient information on the negative aspects (Hyde et al., 2010). Though the advantages of cochlear implants are substantial, it is important to not let them get in the way of seeing the how difficult the decision is for parents. It is a serious matter, and not easy for the parents of

children with profound hearing impairments to make
 immediate choices (Hyde et al., 2010)

Future Considerations

More research is required before professionals have an in-depth understanding of all the variables that are likely to be contributing to very young infants' success with their CIs (Tomblin et al., 2005). Studies to determine how critical early implantation truly is will continue. Professionals will continue to try to determine a definite age or age range to implant children in order to provide the most positive outcome in terms of language development. In addition to the continued study of age, other factors as well need to be investigated. Future research guidelines might include investigating factors that may be tightly linked to the age at which a CI recipient's device is originally stimulated. Other potential studies could further explore more specific aspects of language including phonology, morphology, syntax, and semantic development. Additional studies could examine the effect of early implantation on factors outside of the field of language. For example, are formally educated parents likely to begin the implant process for their children with SNHL much earlier than the parents who have less formal education? Are children with SNHL and no additional disabilities more

likely to be implanted earlier than children with SNHL seeking immediate treatment for multiple disabilities? Another line of research could include a comparison of these young implantees' language outcomes and speech perception outcomes (Tomblin et al., 2005).

Conclusion

In conclusion, the objective of this research paper was to describe the effects of early cochlear implantation on language development of children with pre-lingual sensorineural hearing loss. The normal auditory process, types of hearing loss, hearing aids, and cochlear implants were described to give readers a better understanding. Next, current findings regarding the effects of cochlear implantation at early ages or before the critical language learning years were investigated to determine the most advantageous time for children, as well as parental concerns and how professionals can make the coping process easier for these families. Finally, further research is warranted to determine a more concrete theory on the best age for cochlear implantation.

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